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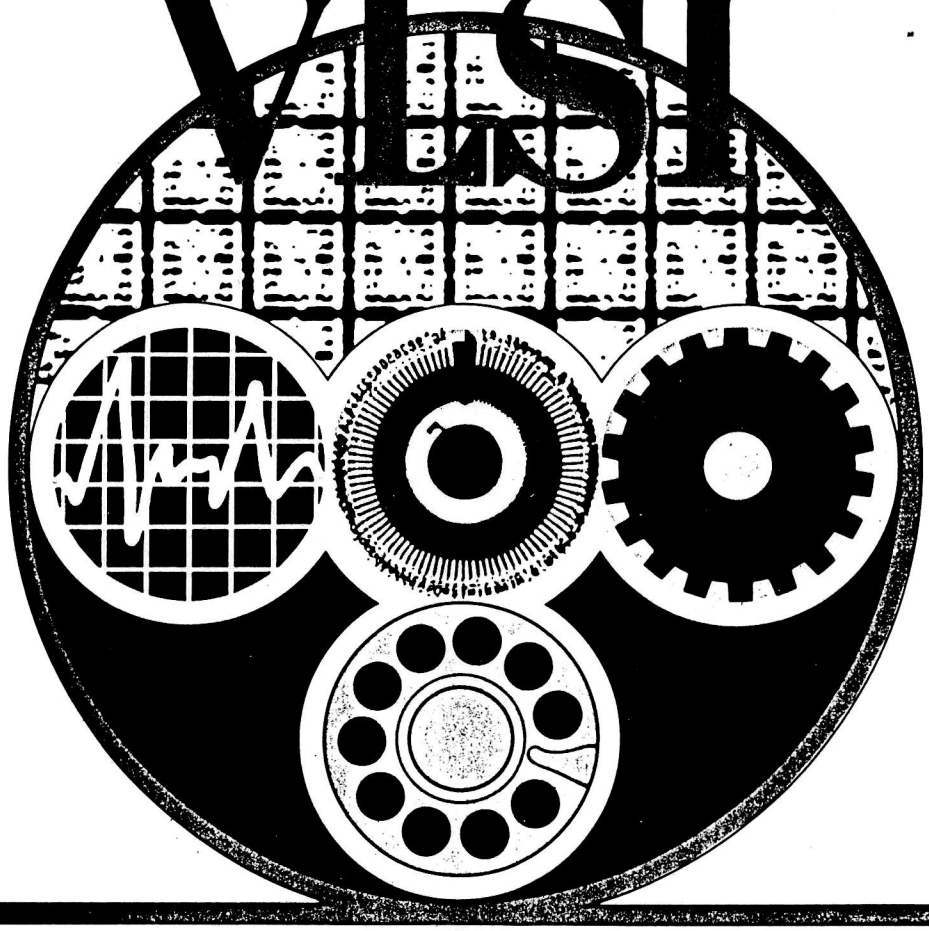

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SESSION 1

LOCAL NETWORKS I

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LOCAL NETWORKS OF PERSONAL COMPUTERS

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The technologies of local computer networks and of personal computers are begining to interact. Local networks enhance sharing and communication in a computer installation. Personal computers make significant dedicated computer power available to the user at a cost that is little more than that of a terminal connected to a more traditional large system.

A commercially available local computer network of personal computers is described here. The system combines the advantages of personal computers (low cost per user, a computer on every desk, etc.) with those of local computer networks (access to shared resources, cost sharing of expensive peripherals, smooth system growth with constant compute power per user.)

Many new capabilities derive from local computer networks such as sharing of data, computer-to-computer communication, and intelligent server resources (shared high-speed printers, file sytems, data-base backends, etc.) This paper discusses the network and internetwork configurations which make such capabilities possible.

INTRODUCTION

Two highly visible recent trends in computer systems are local computer networks [1,2] and personal computers. Local computer networks provide enhanced system capability and effectiveness by allowing:

- computer to computer communication
- data sharing among computers
- cost sharing of expensive electro-mechanical resources (such as printers and mass storage devices)

Personal computers are changing our view of computers by providing:

- very low cost computing
- easy access to computing
- constant computer power per user (independent of time of day, other users, etc.)

To date, however, local computer networks have typically been discussed in the context of large (and expensive) computer system environments; and personal computers have been not been effectively joined into resource sharing networks.

Now however, a new kind of computer system is feasible: a local computer network of personal computers. The goals of such a system should be to provide the advantages of local computer networks in a system that is cost compatible with personal computers. This can be accomplished by combining two strategies. First, the system should be configured using existing components such as popular personal computers and readily available mass storage (disk) devices. Secondly, the software configuration process must be simplified by allowing existing software modules - from operating systems to compilers to data base managers - to make effective use of the network with little or no modification.

A system which meets these goals is the Nestar Systems, Inc. Cluster/One (tm) Model A [3].

TECHNICAL ASPECTS

The design goals of a local network of personal computers are different than those of networks of larger and more expensive computer equipment. In general, cost/performance tradeoff decisions tend to be made in favor of low cost rather than higher performance. This tendency works well with today's personal computers which are themselves designed to be cost effective as opposed to high performance. The result is a local network that is cost compatible with personal work stations (the network connection costs about 15% of a typical station cost) but which can provide somewhat more bandwidth than the stations need (disk I/O to a remote harddisk on the network is faster than disk I/O to local floppy disks, for instance).

Network Implementation

The network is physically implemented by a cable connecting the network stations that is accessed by a network interface card in each station. Data transmission on the network is done 8-bit parallel, allowing eight times the throughput of the equivalent speed serial transmission. Network topology is not restricted; straight line bus, star configuration, or tree structure are all allowed. In keeping with the cost goals, the network interface card does not contain a CPU or

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complex control circuitry. It consists instead of network bus drivers, RAM buffers, and ROM code which is executed by the CPU of the station itself in order to access the network. The network cards of all stations on the network are identical, with the possible exception of different ROM code to implement the higher level protocols.

Message Transmission

Network access control is distributed and contention based (carrier sense, multiple access) as in Ethernet [4]. An individual station desiring to transmit on the network detects whether the network is busy; if not the station transmits its message. The message is a series of transmitted bytes including destination station address, sending station address, message length, (variable length) data, and a checksum.

The destination station computes the checksum of the incoming message and compares that with the received checksum. The receiving station immediately sends an acknowledge/no-acknowledge byte back to the sending station before carrier is dropped. This acknowledge method is different from that of Ethernet, though similar schemes are used in other networks [5]. It has the advantage of immediate acknowledgement to the sending station and relieves the network of the traffic of many separate, short ack/nak messages. Also, multi-packet messages always arrive in order and so packet sequence numbering is unnecessary.

In the event of a collision, when more than one station simultaneously decide that the network is free and both start transmitting, the checksums recieved will not match and the senders will get no-acknowledge and then will retransmit after a random length wait. This method is not as effecient as Ethernet collision detection and backoff, but is simpler to implement and nearly as effective under reasonable network loading.

Station to Station Communication

Using the above hardware message transmission, stations on the network communicate among each other with higher level, software implemented protocols. The underlying packet transmission is used to establish conversations (virtual circuits) or to send single-direction, possibly multi-packet, messages, as appropriate to the higher level function.

Software Integration

As an example of higher levels of communication, stations on the network cooperate with a file server station to use network transmission to implement virtual disk I/O. Network device drivers are integrated into the local user station operating system to do file operations across the network to the remote file server station rather than to local peripherals. This type of transparent integration of the network facilities into the user station environment is critical to the success of local networks of personal computers which will not be installed and operated by sophisticated systems programmers.

SYSTEM ASPECTS

Configurations

The system allows the interconnection of a number (currently up to 64) of personal computers (e.g. Apple II computers [6]) in a local area network (total length up to 1000 feet). The computers on the network are called stations. There is no centralized control. Any number of stations (called servers) may provide services for other stations (called clients) on the network (see figure 1). Typical server functions are discussed below.

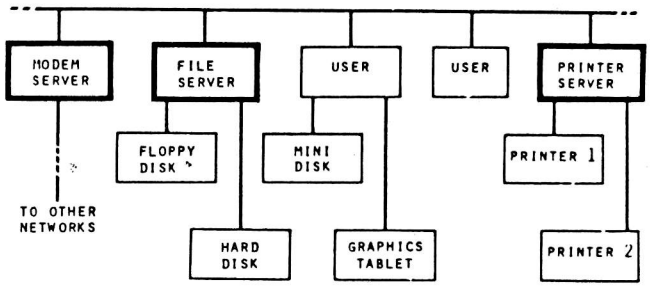

Figure 1. Typical Network Configuration

Servers may also be clients of other servers as appropriate. For instance, the printer server may be a client of the file system server in the course of serving its own clients.

Use of the system can be described from many perspectives. For the designer of end-use systems the network provides a flexible configuration of distributed personal computers that can communicate with each other.

Another view of the system is that it is a society of independent personal computer stations some of which provide known services to other stations.

At a higher level the system may be configured for a specific application, with multiple servers, and applications programs running on the client stations [7,8].

Servers

Typical server functions are:

- file system
- printer support
- time of day clock
- data base management system
- gateway to other networks or computers
- other specialized hardware or software functions

The file server [9,10,11] provided with the system runs on a dedicated network station. It controls floppy disk and hard disk drives (potential total capacity 200 megabytes) attached to that station. The file server software accepts file transaction requests from client stations on the network and accesses the mass storage devices accordingly. The file system provided has a hierarchical structure of directories, password protection for individual files and directories, separate protection for user defined public, group and private access rights, interlocks for safe simultaneous file updates, and all the other characteristics of a state-of-the-art file system.

The file server is viewed by its clients as providing two virtual channels, one for file service metacommands, the other for passing I/O requests and data. The metacommands are used for high level manipulation of the file system, such as creating, deleting, mounting and unmounting files, and locking shared data during simultaneous updating. The virtual I/O channel is used just like a local disc facility. Because the file server has a dedicated processor, it can implement a superset of the I/O facilities normally provided by the local operating system. For instance, in the system presented here, the local operating system normally restricts its users to two disks mounted per channel; the file server allows up to 255 simultaneous mounted files.

The file server thus provides for its client stations a file facility which:

- is two orders of magnitude larger than file systems supported locally
- is faster than standard local disk drives
- has more sophisticated structure than local file systems
- allows protection of private data
- allows controlled sharing of data with other stations.

Print service is provided by a network station with one or more printers attached running software which accepts print requests from the network and maintains a print request queue on the file server. On request, the print server finds a file on the specified file server and prints it on the specified printer. A typical print server has several printers, one for drafts and listings, another for letter quality final copy.

Internets

The locality limitations of local networks can be relieved by providing communication links between networks. Several types of internetwork servers (gateways) may be appropriate. A simple gateway called a file transfer server is a generalization of the printer server discussed above. A file transfer server is directly attached to several local networks. It fields file transfer requests from each network and transfers files either to its attached printers or to file servers or user stations on another network.

Long distance internetwork communication is provided by a modem server containing auto-dial/auto-answer modems and data transfer software for inter-network transmission. Figure 2 shows a possible internetwork configuration.

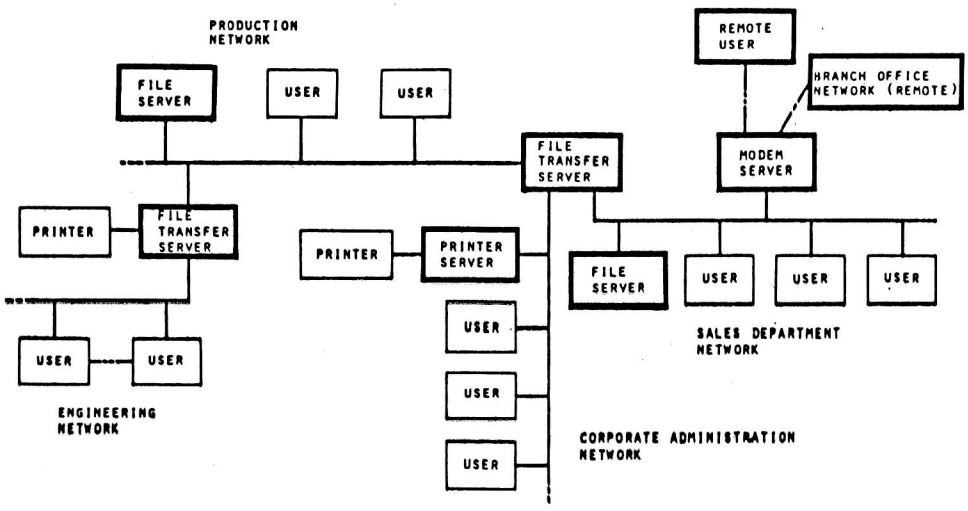

Figure 2. Typical Internetwork Configuration

SUMMARY

Local networks of personal computers can be used in a wide variety of ways [7,8]. Distributed applications such as electronic mail [12] and others are available for use with the system.

The Nestar Systems Cluster/One (tm) Model A has been commercially available since the second quarter of 1980. It offers the advantages of local networks in the context of low cost, readily available, user-friendly personal computers. The system supports a large existing software base with no conversion, and it provides shared access to expensive and sophisticated resources not normally available for individual personal computers.

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